SEAT SPECIFIC TECHNIQUE IN PAIR OARED ROWING

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Biomechanical analyses were conducted on ten established pair combinations to determine if evidence existed to support the theory of seat specific rowing technique. No statistically significant differences were found between stern and bow seat rowers in the variables analysed, but sufficient evidence existed to warrant further investigation into this issue. When two rowers who demonstrated the appropriate seat specific technique were combined, the improvement in average boat velocity was 8 standard deviations greater than the control group mean. It was concluded that the improved boat velocity produced by this crew was at least partially due to the combination of rowers who exhibited the appropriate seat specific technique.

KEY WORDS: rowing, technique optimisation

INTRODUCTION: Biomechanists measuring individual force-time data during ergometer and on-water rowing trials have assumed that optimal boat propulsion would result from a uniform pattern of force application from all crew members (Asami et al., 1978; Mason et al., 1988; Wing and Woodburn, 1995). Similarity in force-time profiles was considered to be the most effective method of propelling the rowing shell as this minimised the introduction of turning moments on the boat resulting from poorly synchronised or unequal forces (Wing and Woodburn, 1995).
In contrast, others have claimed that effective boat propulsion in a pair oared boat required the force-time histories of each rower to differ with regard to shape and timing (Schneider et al., 1978; Zatsiorsky and Yakunin, 1991; Roth, 1991). In order to reduce intracycle deviations off course, the rower in the stern of the boat needed to produce more work and reach a greater peak force with the oar closer to the catch position, when compared to the bow seat rower. Schneider et al. (1978) explained that the geometry of the pair racing shell and the movement of the total centre of mass during the stroke cycle necessitated asynchrony in the individual impulses. The challenge was to correctly match the biomechanical attributes of each rower with the specific requirements of each boat position.
The first objective of this study was to determine if experienced rowers in a pair rowing boat demonstrated seat specific rowing technique. A secondary objective was to manipulate crew composition to determine if performance could be enhanced by combining rowers who exhibited the theoretically ideal seat specific technique.

METHODS: The subjects for this study were 20 competitive male rowers who had been training in established pair combinations prior to enrolling in this study. The subjects signed a written informed consent before participating in one on-water biomechanical assessment and two race simulations. The on-water sessions required each crew to perform a 500 m trial (rowing at 28 spm) in a standard coxless pair rowing boat which had been instrumented to measure oarlock force, oar angular displacement, and boat velocity. Data were sampled continuously at 101.18 Hz.
Analyses were performed on 15 consecutive strokes selected from the mid point of each 500 m trial. Individual cycles (catch to catch) were normalised to 100 data points and averaged. Variables were selected to detect differences between stern and bow seat rowers in oar force application and work production based upon the theory of seat specific rowing technique. These included peak oarlock force, oar angle at peak force, average work per stroke, the percentage of the total work done between catch and peak force and the percentage of the total work done from catch to the orthogonal position of the oar. Work done by each rower was further assessed by the percentage of the total work done in each third of the drive phase. All

crews then participated in a 2,000 m race and time to cover the distance was used to rank crews under race conditions.

Basic descriptive statistics were conducted to establish normative data for the sample of stern and bow seat rowers and differences were detected using separate t tests for independent means. Group mean data were compared using a modified Bonferroni technique with an alpha level of .03.

In the second phase of the study, the normalised average data from all 20 rowers were visually evaluated and two new crews were created. Two subjects with similar rowing technique were combined to test the assumption that similarity in force-time profiles enhanced rowing performance. The second crew was created to test the theory of seat specific rowing technique, and combined a stern seat rower who applied a force early in the stroke with a partner who emphasised the second half of the stroke cycle. The new crew combinations undertook five supervised training sessions before a 1,750 m time trial was conducted to assess changes in rowing performance. Four unaltered crews from the original group served as controls for the comparison of race results.

RESULTS AND DISCUSSION: Comparison of stern and bow seat rowers: Analysis of group results confirmed that although no statistically significant differences were detected between the group of stern and bow seat rowers, the stern seat rowers generated a greater peak oarlock force (Table 1). This aspect of seat specific technique has been reported in force measured on the oarlock pin (Roth et al., 1993) and propulsive force calculated on the oar blade (Schneider et al., 1978). Although stern and bow seat rowers attained peak oarlock force at approximately 54% of the complete stroke cycle, the oar position at which the maximum force occurred differed with athlete position within the boat. The stern rowers attained this peak oarlock force at an average oar angle of 15.3^o ($\pm$ 5.38) before the orthogonal position which was an average of 3.8 degrees closer to the catch position when compared to the group of bow rowers. The peak oarlock force for the stern rower preceded that of his partner in six of the ten crews analysed and the differential ranged from 1.55 ^{o} to 14.78 ^{o}. Zatsiorsky and Yakunin (1991) reported that boat directional deviations would be reduced if the stern seat rower attained a peak force 20 to 30^o prior to his partner. The magnitude of this discrepancy is surprising as total oar angular displacement during one stroke typically ranges between 80 and 90^o (McBride, 1998).

Table 1 Statistical Comparison of Stern and Bow Seat Rowers (mean $\pm$ s.d.)

	stern seat rower	bow seat rower	p level
Peak oarlock force (N)	976.0 (121.70)	857.59 (103.83)	.031
Timing of peak force (% cycle)	53.6 (2.07)	54.2 (2.34)	.552
Oar angle at peak oar force (degree)	-15.3 (5.38)	-11.5 (4.74)	.115
Average work per stroke (J)	655.08 (68.55)	589.38 (74.99)	.055
% of total work - catch to orthogonal (%)	75.22 (7.28)	69.99 (6.23)	.103
% of total work - catch to peak force (%)	50.87 (6.91)	50.74 (4.62)	.962

Work done in an average stroke has not been quantified in the research associated with the theory of seat specific technique, but visual inspection of the graphical data presented in the literature indicated that the stern seat rower should generate more total work and the first half of the stroke should be emphasised. When compared to the bow seat rowers, results confirmed that the stern seat rowers performed more total work and a greater percentage of the work was done before the oar reached the orthogonal position (Table 1). No differences were found between the two groups when comparisons were made in the percentage of total work performed between the catch and peak oarlock force. The two groups of rowers were virtually indistinguishable when total work was partitioned into three equal components.

Created crew data: The data from each of the 20 subjects were evaluated and two new crews were created. The 15 stroke average data for the selected rowers are presented for the crew created to demonstrate seat specific technique (Figure 1a), and the crew demonstrating similar rowing technique (Figure 1b). It must be reinforced that the data presented in Figure 1 were collected while each rower performed with his original training partner. It was therefore not surprising to find some temporal aspects of the data were not perfectly synchronized.

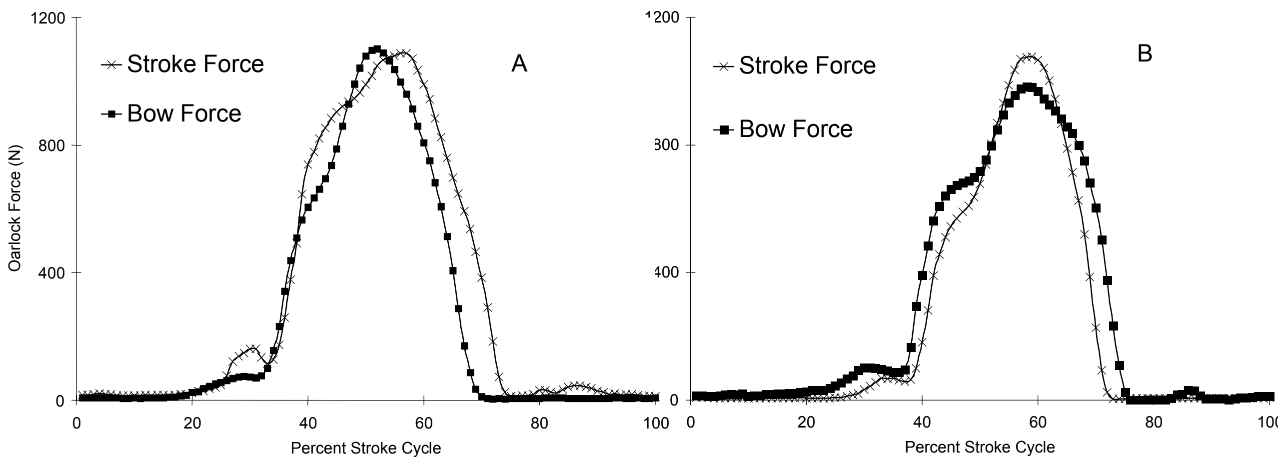

Figure 1 - Created crew combinations based upon the theory of seat specific technique (1a), and similar rowing technique (1b).

The average boat velocity for the control and created crews are provided for both race conditions (Table 2). As each of the rowers in the created crews were initially from two different original crews, both average velocities were provided for the 2,000 m race condition and the mean value was used to determine the percent improvement for the 1,750 m race condition. Coincidentally, the two new crews were created by simply exchanging rowers from two original crews. All crews demonstrated greater average boat velocity during the 1750 m condition with the average boat velocity for the control crews improved by 6.96 % (± 0.52).

Table 2 Average Boat Velocity (± s.d.) for Control and Created Crews for Both Race Conditions

	2,000 m (m/s)	1,750 m (m/s)	Difference (%)
Control Crews (n=4)	4.27 (± 0.11)	4.54 (± 0.11)	+ 6.96 (± 0.52)
Similar Crew	stern = 4.39 bow = 4.38	4.64	+ 5.82 %
Seat Specific Crew	stern = 4.39 bow = 4.38	4.87	+ 11.01 %

The average boat velocity for the “similar” crew improved by 5.82% for the 1,750 m condition, but this improvement was 2.2 standard deviations less than the control group mean. In contrast, the crew created to test the theory of seat specific technique demonstrated an 11.1% improvement which was 8 standard deviations greater than the control group mean.

CONCLUSIONS: The first of the studies presented was designed to determine if evidence existed to support the theory of seat specific technique in pair rowing. Although the analysis of results did not provide statistical verification, trends in the data produced sufficient evidence to warrant further investigation into this issue. It was hypothesised that rowers in established pair combinations would exhibit "seat specific" technique, but it was discovered that established crews exhibited a full spectrum of individual and crew techniques. The development of seat specific rowing technique may evolve over years of rowing in the same position within the boat and a comprehensive biomechanical evaluation of international calibre rowers who train exclusively in the coxless pair should be attempted to determine if rowing success requires the adoption of seat specific technique.

When biomechanical data were used to create new crew combinations, performance was enhanced when two rowers who demonstrated the appropriate seat specific technique were partnered. In contrast, the selection of two rowers with a uniform force-time history was found to be detrimental to performance. It was concluded that effective boat propulsion may be dependent upon the selection of rowers who naturally exhibit seat specific technique which would create the optimal balance of crew forces necessary to improve boat velocity.

REFERENCES:

Asami, T., Adachi, , N., Yamamoto, K., Ikuta, K., & Takahaski, K. (1978). Biomechanical analysis of rowing skill. In E. Asmussen and K. Jorgensen (Eds.), *Biomechanics VI-B,* Proceedings of the Sixth International Symposium on Biomechanics, (pp. 109-114). Copenhagen, Denmark, 1977. Baltimore, MD: University Park Press.

Mason, B.R., Shakespear, P., & Doherty, P. (1988). The use of biomechanical analysis in rowing to monitor the effect of training. *Excel*, 4 (4), 7-11.

McBride, M.E. (1998). *The role of individual and crew technique in the enhancement of boat velocity in rowing*. Unpublished doctoral thesis, University of Western Australia, Perth, Australia.

Roth, W. (1991). Physiological-biomechanical aspects of the load development and force implementation in rowing. *FISA Coach*, 2 (4), 1-9.

Roth, W., Schwanitz, P., Pas, P., & Bauer, P. (1993). Force-time characteristics of the rowing stroke and corresponding physiological muscle adaptations. *International Journal of Sports Medicine*, 14, S32-S34.

Schneider, , E., Angst, F., & Brandt, J.D. (1978). Biomechanics in rowing. In E. Asmussen and K. Jorgensen (Eds.), *Biomechanics VI-B*, Proceedings of the Sixth International Symposium on Biomechanics, (pp. 115-119). Copenhagen, Denmark, 1977. Baltimore, MD: University Park Press.

Wing, A.M. & Woodburn, C. (1995). The coordination and consistency of rowers in a racing eight. *Journal of Sports Sciences*, 13, 187-197.

Zatsiorsky, V.M. & Yakunin, N. (1991). Mechanics and biomechanics of rowing: A review. *International Journal of Sport Biomechanics*, 7, 229-281.